Remarks

Reconsideration of this application is requested in view of the foregoing amendments and the following remarks.

Applicants appreciate the search performed by the examiner in performing a substantive examination of the claims.

Claims 1-10, 21-32, 34-37, 44-50, 52-54, and 56-77 are pending. In this paper, claims 1-6, 8-10, 21-22, 24-26, 28-30, 32, 35-37, 46, 48-50, 53-54, 67-68, 73, and 77 are amended; claims 7, 23, 27, 31, 34, 47, 52, 56, 60, 64-66, 69-72, and 74-76 are unchanged; claims 11-20, 33, 38-45, 51, 55, 57-59, and 61-63 are canceled without prejudice; and new claims 78-86 are submitted for consideration.

The amendments to the specification are to correct readily discernible errors. No new matter is submitted.

Support for the amendments to independent claim 1, for example, can be found in the specification on page 3, lines 10-16; page 10, lines 22-24; page 11, lines 22-25; page 12, line 11 to page 14, line 16; page 15, lines 9 and 14-18; page 20, lines 19-26; page 21, lines 9-17; and page 22, lines 3-29. Also, part of claim 5 was added to claim 1. Claims 2-6 and 8-10 are amended in view of the amendments to claim 1 and to further clarify the subject matter being claimed. Independent claim 21 is amended in a manner similar to certain amendments to claim 1. Claims 22, 24-26, 28-30, 32, 35-37, 67-68, and 73 are amended in view of the amendments to claim 21. New claims 78-86, which depend from claim 1, are specifically directed to respective possible specific configurations of the claimed apparatus. Independent claim 46 is amended in a manner similar to certain amendments to claim 1. Claims 48-50, 53-54, and 77 are amended in view of the amendments to claim 46.

The rejection of claims 45, 57-59, and 61-63 under 35 U.S.C. §112, ¶2, is moot in view of the cancellation of these claims. Also, the rejection of claims 32 and 67-68 under similar grounds is moot in view of the amendments to these claims.

Claims 1-8, 21-28, 32, 46-50, 64, 68-69, and 74 stand rejected for alleged anticipation (35 U.S.C. §102(b)) by Wyant et al., U.S. Patent 4,639,139 ("Wyant"). This rejection is traversed.

Turning first to claims 1-8, the apparatus of claim 1 as amended includes, *inter alia*: (1) a phase-state stepping device that is situated and configured to move, in stepwise increments, at least one of the target object and the reference surface relative to respective initial positions of the target object and reference surface so as to change, relative to an initial phase relation obtained at the respective initial positions, the phase relation of noise light relative to at least one of the reference-light flux and the measurement-light flux from the target object. These stepwise increments and the initial positions represent multiple respective phase-state positions in a range of 0 to 2π. The apparatus also includes (2) a phase-modulation device situated and configured to produce a phase modulation of at least one of the reference-light flux and the measurement-light flux. The apparatus also includes (3) a detector situated and configured to detect interference fringes produced by the interference at the phase-state positions in the range. The apparatus also includes (4) a computer connected to the detector and configured to produce, from the detected interference fringes produced at the respective phase-state positions, data concerning the respective phase distributions. The computer also is configured to calculate an average (mean) phase distribution from the respective phase distributions.

For example, the device of claim 1 can produce the phase distributions: D_0, D_1, D_2, and D_3 at the 0, $\pi/2$, π, and $3\pi/2$ phase-state positions, respectively, as achieved by motions imparted by the phase-state stepping device. Each phase distribution is determined by phase-shift interferometry, as achieved by the phase modulations produced by the phase-modulation device. Respective intensity distributions for the phase distributions can be denoted: for D_0: I_{00}, I_{01}, I_{02}, I_{03}; for D_1: I_{10}, I_{11}, I_{12}, I_{13}; for D_2: I_{20}, I_{21}, I_{22}, I_{23}; and for D_3: I_{30}, I_{31}, I_{32}, I_{33}. (D_0 is obtained at the initial ("0") phase-state position(s).) Hence, for example, $D_0 = \tan^{-1}[(I_{00} - I_{02})/(I_{01} - I_{03})]$; $D_1 = \tan^{-1}[(I_{10} - I_{12})/(I_{11} - I_{13})]$; $D_2 = \tan^{-1}[(I_{20} - I_{22})/(I_{21} - I_{23})]$; and $D_3 = \tan^{-1}[(I_{30} - I_{32})/(I_{31} - I_{33})]$. The mean distribution D_A is calculated: $D_A = (D_0 + D_1 + D_2 + D_3)/4$. This averaging results in a calculated phase distribution that is unusually free of the effects of noise light, and thus more accurately reflects the true phase distribution. See page 12, line 11 to page 14, line 16 of the instant specification.

Note that, in claim 1 and its dependents, the phase-stepping device can impart the claimed motion to only the target object, to only the reference surface, or to both the target object and the reference surface. Any of these three stepping motions can yield respective distributions

that, when averaged, substantially eliminate the quantitative effects of noise light on any of the individual distributions.

Wyant is limited to an improvement in the phase-shift interference technique, but provides no hint whatsoever of eliminating the effects of noise light, ways in which such elimination can or could be achieved, or of any reasons why such elimination is important or desirable. More specifically, Wyant discloses an improved integrated bucket technique for obtaining an interferogram in phase-shift interferometry. Col. 2, lines 29-32. For example, first, second, and third integrated buckets are used to compute a first phase value of a particular interference pattern; and second, third, and fourth integrated buckets are used to compute a second phase value of the interference pattern. The first and second phase values are averaged, which serves to cancel sinusoidal error caused by imprecise 90° phase changes during which the integrated buckets for each photodetector are produced. See col. 1, lines 65 to col. 2, line 1; col. 3, lines 31-40; col. 8, lines 49-55. But, Wyant provides no teaching, suggestion, or hint whatsoever, in the context of performing phase-shift interferometry, of: (a) employing a phase-state stepping device in the manner claimed and (b) configuring a computer to calculate an average phase distribution from respective phase distributions.

In the Wyant apparatus, the position of the reference surface relative to the test surface is ramped, in accordance with the graph shown in FIG. 2 of that reference, so as to achieve the phase modulation required for producing an interferogram. See col. 1, lines 34-40; col. 3, lines 2-6; col. 4, lines 48-53; col. 12, lines 3-43. Such movement of the reference surface is commonly performed in phase-shift interferometry. In Wyant the ramp width is 2π (360°), and the integrated buckets are discharged into a shift register at each 90° increment in the ramp. Col. 5, line 40 to col. 6, line 11; FIG. 2A. See also FIG. 2B and col. 6, lines 21-34. After completing the full-ramp phase modulation, the reference surface is returned to its initial position prior to beginning a new cycle of phase modulation. Col. 6, lines 43-46. But, this disclosure in Wyant does not hint at, and does not lead to obtaining, in addition to this phase modulation, multiple interferograms at respective phase-state positions and calculating an average phase distribution, as instantly claimed, from them for any purpose. Wyant also does not teach or suggest a phase-stepping device, as claimed, in addition to a phase-modulation device. As a result, claim 1 and its dependent claims are properly allowable over Wyant.

The method of claim 21 as amended includes, *inter alia*, producing a phase-distribution interference pattern associated with a target object. This interference pattern is produced by phase-shift interference. The interference pattern is produced at initial respective positions of the reference surface and target object (representing an initial phase state). Interference patterns also are obtained after each movement of at least one of a standard surface and the target object a respective specified distance from the respective initial position, wherein the specified distance(s) are appropriate to change the phase state of the at least one of the reference and measurement light fluxes a specified amount in a stepwise manner in the range of 0 to 2π relative to the initial phase state. At each of these phase states, steps (a)-(d) in the claim are repeated to obtain respective phase distributions at each of the multiple specified distances. A calculation is made to determine the average phase distribution from the respective phase-distribution interference patterns obtained at the phase states. Hence, it can be seen that this claim, directed to a method rather than to a corresponding apparatus, shares many similarities to claim 1, discussed above, and that claim 21 is clearly distinguishable over Wyant for the reasons discussed above regarding claim 1. Therefore, claim 21 and its dependents are properly allowable over Wyant.

The apparatus of independent claim 46 includes an optical system that produces, from the light flux generated by a light source, a measurement-light flux and a reference-light flux. The optical system directs the measurement-light flux to the target object so as to cause the measurement-light flux to interact with the target object and thus acquire a wavefront profile corresponding to the optical characteristic of the target object. The optical system directs the reference-light flux to interact with a reference surface so as to provide the reference-light flux with a reference wavefront. The optical system also establishes an interference between the reference-light flux from the reference surface and the measurement-light flux from the target object, and directs the interfering reference-light flux and measurement-light flux to the detector. The apparatus also includes a first actuator situated and configured to move the reference surface and optionally also the target object a respective specified distance in a stepwise manner from a respective initial phase-state location, wherein the respective specified distance is appropriate to change the phase state of the at least one of the light fluxes a specified amount in a stepwise manner in a range of 0 to 2π relative to the initial phase-state location. The apparatus includes a second actuator that is situated and configured to produce a phase modulation between the

reference-light flux and the measurement-light flux (e.g., in the manner normally employed in phase-shift interferometry). The apparatus also includes a phase-detection device connected to the detector and configured to detect respective phase differences in the detected light at each of the specified distances based on the phase-modulation. The apparatus also includes a computer configured to determine respective phase distributions from the respective phase differences at each of the specified distances and to calculate, from the respective phase distributions, an average phase distribution, wherein the average phase distribution corresponds to a measurement of the optical characteristic. Hence, it can be seen that this claim shares many similarities to claim 1, discussed above, and that claim 46 is clearly distinguishable over Wyant for the reasons discussed above regarding claim 1. Therefore, claim 46 and its dependents are properly allowable over Wyant.

Claims 1, 21, 34, 46, 52, 57-63, 65, 67, 70-72, and 75-76 stand rejected for alleged anticipation (35 U.S.C. §102(b)) by Suzuki et al., U.S. Patent 5,898,501 ("Suzuki"). This rejection is traversed, as discussed below. Also, the rejection is moot with respect to canceled claims 57-59 and 61-63.

The combination of features recited in claim 1 as amended is discussed above. Whereas Suzuki discloses apparatus and methods for measuring wavefront aberrations using a phase-shift interferometer, Suzuki does not teach or suggest including, with the disclosed phase-shift interferometer, a phase-state stepping device that is configured as recited in claim 1. Suzuki also does not teach or suggest a computer configured in the manner recited in claim 1, namely to produce data concerning respective phase distributions obtained at the various phase-state positions and to calculate an average phase distribution from the respective phase distributions. Furthermore, Suzuki is completely silent on the particular problem addressed by the apparatus of claim 1 (namely, offsetting the contributions of noise light to phase-shift interferograms). Suzuki also is silent on any possible manner in which such a problem can be solved, and of any need or desirability of solving such a problem. Hence, claim 1 and its dependents are clearly allowable over Suzuki.

The combination of steps recited in independent claim 21 is summarized above, as are the shortcomings of Suzuki. Since, *inter alia*, this claim is largely a method counterpart to claim 1, claim 21 and its dependents are properly allowable over Suzuki for all the reasons discussed above pertaining to claim 1.

The combination of features recited in independent claim 46 is discussed above, as are the shortcomings of Suzuki. This claim is not anticipated by or obvious from Suzuki for reasons similar to the reasons for which claim 46 is properly allowable over Wyant. Therefore, claim 46 and its dependents are properly allowable over Suzuki.

Claims 9-10, 29-31, 44, 56, and 66 stand rejected for alleged obviousness in view of Wyant, and claims 35-37, 53, 54, 73, and 77 stand rejected for alleged obviousness in view of Suzuki. This rejection is traversed. These claims all depend from allowable base claims, as discussed above, and hence are properly allowable.

In view of the preceding amendments and remarks, all pending claims are in condition for allowance and action to such end is requested.

Respectfully submitted,

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